



# The Relationship between Superior Disc-Endplate Complex Injury and Correction Loss in Young Adult Patients with Thoracolumbar Stable Burst Fracture

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**Background:** To determine the relationship between superior disc-endplate complex injury and correction loss after surgery in a group of young adult patients with a stable thoracolumbar burst fracture.

**Methods:** The study group was comprised of young adult patients who had undergone short-segment posterior fixation and bone grafting under the diagnosis of a stable thoracolumbar burst fracture from March 2008 to February 2014. Follow-up was available for more than 1 year. Before surgery, magnetic resonance imaging was performed to determine injury to the anterior longitudinal ligament, posterior longitudinal ligament, and superior and inferior intervertebral discs and endplates. Correction loss was evaluated by the Cobb angle, intervertebral disc height, upper intervertebral disc angle, vertebral wedge angle, and vertebral body height.

**Results:** No significant relation was noted between correction loss and an injury to the anterior longitudinal ligament, posterior longitudinal ligament, inferior intervertebral disc/endplate, and fracture site, whereas an injury to the superior endplate alone and superior disc-endplate complex showed a significant association. Specifically, a superior intervertebral disc-endplate complex injury showed statistically significant relation to postoperative changes in Cobb angle ( $p = 0.026$ ) and vertebral wedge angle ( $p = 0.047$ ).

**Conclusions:** A superior intervertebral disc-endplate complex injury may have an influence on the prognosis after short-segment fixation in young adult patients with a stable thoracolumbar burst fracture.

**Keywords:** *Stable burst fracture, Short segment fusion, Correction loss*

Spinal fractures commonly occur in the thoracolumbar region, with burst fractures accounting for 21% to 58% of all thoracolumbar fractures.<sup>1-3)</sup> Most authors believe that burst fractures require surgical intervention; however, there is some controversy regarding treatment.<sup>4,5)</sup> Advances in spinal instrumentation have brought short-segment instrumentation into successful clinical practice.

Among the surgical methods for thoracolumbar burst fractures, short-segment pedicle screw fixation (SSPSF) is the most common and simple treatment option.<sup>6)</sup> On the other hand, many studies have shown that SSPSF alone led to a high incidence of implant failure and kyphosis recurrence, which accounted for approximately 9% to 54%.<sup>7)</sup> Moreover, collapse of the disc space and recurrent kyphosis are commonly observed after instrumented reduction of thoracolumbar vertebral burst fractures.<sup>7,8)</sup> Whether correction loss can be influenced mainly by the fractured vertebral body or the disc-endplate complex is uncertain. This study examined the relationship between superior disc-endplate complex (SDEC) injury and reduction loss after SSPSF in a group of young adult patients with stable

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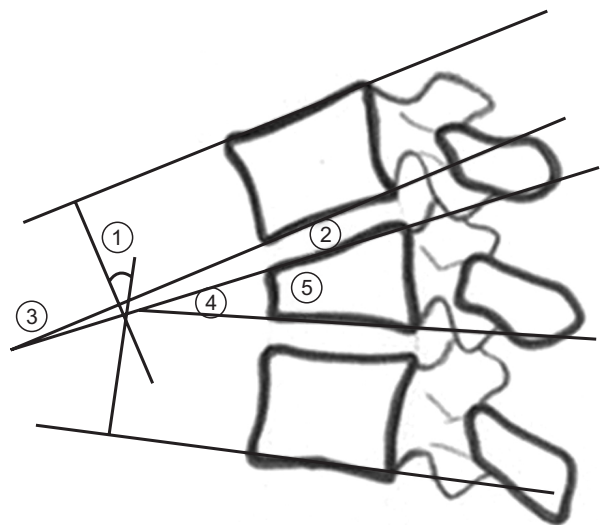
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thoracolumbar burst fractures (STLBFs).

## METHODS

This study reviewed retrospectively 37 patients followed up for a minimum of 1 year among adult patients younger than age 45 years who had undergone short-segment posterior fixation and allograft after being diagnosed with a stable burst fracture of the thoracolumbar spine from March 2008 to February 2014. A stable burst fracture is a descriptive term for compressive injury to the anterior and middle columns of the vertebral body due to axial compression, and the posterior column is typically normal or associated with a vertical fracture of the vertebral arch. The indications for surgery were the patient wanting to return to his/her daily life early and presence of one or more of the following three radiological findings: (1) 30% or higher compression rate of the fractured anterior column of the vertebral body; (2) sagittal index of 15° or greater (sagittal index is the measurement of kyphosis at a motion segment [1 vertebra and 1 disc] adjusted for the baseline sagittal contour at the level); and (3) invasion of bone fragments into the spinal canal by 30%. For kyphosis correction and reduction of the collapsed vertebral body, fixation was performed using the mono-axial pedicle screw system by bending a metal rod for a slight overcorrection of kyphosis after inserting pedicle screws parallel to the epiphyseal plate into the normal vertebral bodies located superior and inferior to the fractured vertebral body. In all cases, bone allograft was performed through the dorsal portion of the lamina after decortication to support the fractured vertebra. All procedures were conducted by a single spine surgeon (KYL) using the same surgical technique. The surgical instrument used was a posterior vertebral fixation device (Mega Spine set from BK Meditech, Hwaseong, Korea). All patients were placed on bed rest for an average of 2.2 days (range, 1 to 3 days) after surgery, and were allowed to start ambulation using ambulatory assistive devices. After confirming bone union or stabilization of the fractured vertebra at an outpatient follow-up, the assistive devices were removed at 11.7 weeks postoperation on average. The degree of postoperation reduction loss was assessed by examining the Cobb angle (CA), intervertebral disc height (IDH), upper intervertebral disc angle (UIDA), vertebral wedge angle (VWA), and anterior vertebral body height (AVBH) on the radiographs taken immediately and 1 year after surgery, and the changes were calculated. Measurements were performed three times each by two spine specialists using a digital ruler and a protractor on the true lateral views of the spine radiographs taken precisely using

a picture archiving and communication system. The intraclass correlation coefficient between the two observers was calculated as 0.873 (range, 0.796 to 0.925) indicating a high agreement. Thus, the average of the measurements obtained by two observers was used for analysis. The CA was measured between the superior margin of the upper vertebra and the inferior margin of the lower vertebra included in spine fusion. The IDH was defined as the minimum distance between the superior margin of the injured vertebra and the inferior margin of the upper vertebra. The UIDA was measured between the superior margin of the vertebra and the inferior margin of the upper vertebra at the hinge area in a wedge-shaped deformity of the injured spine after fracture. The VWA was defined as the angle between the superior margin and the inferior margin of the injured vertebral body, while the AVBH was defined as the height of the anterior vertebral body of the fractured area (Fig. 1). To explore the relationship between injury to the vertebral structures and the degree of reduction loss, the presence of injuries to the anterior longitudinal ligament (ALL), posterior longitudinal ligament (PLL), and the superior and inferior discs and endplates was examined based on the preoperative magnetic resonance imaging (MRI) findings (Fig. 2). An injury was defined as any continuity loss of each structure, signal change, or edema.<sup>9)</sup> The impacts of the injuries of the ALL, PLL, fractured vertebral area, superior disc, superior endplate, inferior disc, and inferior endplate on radiological reduction loss were evaluated. Furthermore, the different effects of SDEC



**Fig. 1.** Radiological evaluation using plain lateral radiography. ①: Cobb angle, ②: intervertebral disc height, ③: upper intervertebral disc angle, ④: vertebral wedge angle, ⑤: anterior vertebral body height.

injury and superior endplate injury alone on radiological reduction loss were compared based on the assessment of changes for radiological parameters.

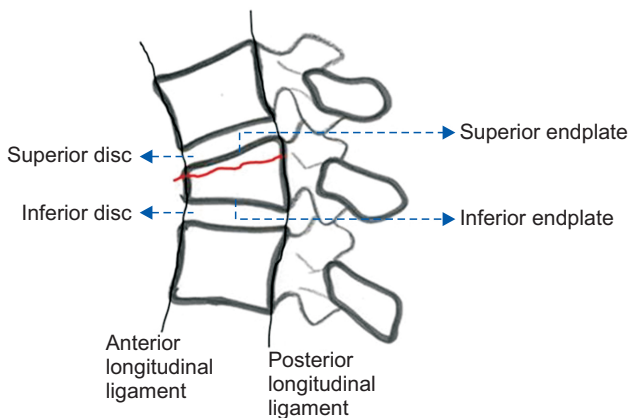
All statistical analyses were performed using IBM SPSS ver. 19.0 (IBM Corp., Armonk, NY, USA). To determine statistical significance, a Mann-Whitney *U*-test was used for comparison of two variables, and a Kruskal-Wallis test was used for comparison of more than three variables.

We conducted this study in compliance with the principles of the Declaration of Helsinki. The protocol of this study was reviewed and approved by the Institutional Review Board of Dong-A University Hospital (IRB No. DMC 2017-09-013-001). The informed consent was

waived.

## RESULTS

A total of 37 subjects (26 male and 11 female patients) were enrolled in this study. Their mean age was 37.2 years (range, 21 to 44 years). The causes of injury were falls in 27 cases, traffic accidents in nine, and blunt trauma by the impact of an object in one. The mean duration from injury to surgery was 4.7 days, and the mean follow-up was 13.4 months. On the preoperative MRI scans, the ALL was injured in 35 cases and not injured in two, whereas the PLL was injured in 30 cases and not injured in seven. The most frequently injured level was L1 in 16 cases, followed in order by L2 in eight cases, L3 in six, T12 in four, and L4 in three. On the superior endplate injuries, injury to both the disc and endplate regions was observed in 20 cases; the endplate alone was injured in 12; and no injury was present in five. On the inferior endplate injuries, both the disc and endplate were injured in four cases; injury to the endplate alone was observed in five, and none of these areas was injured in 28. Statistical analysis data on the impact of the presence of injuries on radiological parameters of reduction loss are presented in Tables 1 and 2. No significant relation was observed between reduction loss and the ALL or PLL injury, level of the fractured vertebra, and injury to the inferior disc/endplate. On the other hand, there was a statistically significant difference in the change of CA ( $p = 0.026$ ) among patients with the superior endplate injury



**Fig. 2.** Radiological evaluations using T2-weighted sagittal magnetic resonance imaging.

**Table 1.** Factors Affecting the Change of Radiologic Parameters

Presence of injury	No.	Cobb angle difference		Disc height difference		Upper intervertebral disc angle difference		Vertebral wedge angle difference		Anterior vertebral body height difference		
		Mean $\pm$ SD	<i>p</i> -value	Mean $\pm$ SD	<i>p</i> -value	Mean $\pm$ SD	<i>p</i> -value	Mean $\pm$ SD	<i>p</i> -value	Mean $\pm$ SD	<i>p</i> -value	
ALL	○	35	11.6 $\pm$ 2.2	0.168	1.6 $\pm$ 1.9	0.363	3.8 $\pm$ 3.0	0.243	6.9 $\pm$ 2.7	0.508	1.5 $\pm$ 1.6	0.589
	×	2	3.3 $\pm$ 1.6		2.9 $\pm$ 1.2		7.9 $\pm$ 2.2		9.7 $\pm$ 3.9		0.1 $\pm$ 1.3	
PLL	○	30	10.6 $\pm$ 3.4	0.835	1.5 $\pm$ 2.2	0.293	3.6 $\pm$ 2.0	0.100	6.9 $\pm$ 3.8	0.690	1.1 $\pm$ 2.5	0.531
	×	7	13.5 $\pm$ 3.9		2.3 $\pm$ 1.7		5.9 $\pm$ 2.7		7.7 $\pm$ 2.4		2.4 $\pm$ 1.6	
Level	L1	16	11.9 $\pm$ 5.4	0.123	1.6 $\pm$ 1.4	0.843	4.2 $\pm$ 1.6	0.828	5.9 $\pm$ 3.3	0.268	1.6 $\pm$ 2.8	0.564
	L2	8	11.0 $\pm$ 6.5		1.6 $\pm$ 2.7		3.3 $\pm$ 2.0		8.5 $\pm$ 4.0		0.2 $\pm$ 4.8	
	L3	6	10.8 $\pm$ 4.6		1.2 $\pm$ 1.1		4.8 $\pm$ 2.3		6.5 $\pm$ 4.6		0.4 $\pm$ 4.0	
	L4	3	1.5 $\pm$ 1.9		1.6 $\pm$ 1.1		4.0 $\pm$ 3.1		1.7 $\pm$ 3.4		3.3 $\pm$ 2.1	
	T12	4	16.8 $\pm$ 5.0		2.4 $\pm$ 1.6		3.6 $\pm$ 2.4		13.9 $\pm$ 7.4		3.0 $\pm$ 1.8	

SD: standard deviation, ALL: anterior longitudinal ligament, PLL: posterior longitudinal ligament.

**Table 2.** Factors Affecting the Change of Radiologic Parameters

Presence of injury	No.	Cobb angle difference		Intervertebral disc height difference		Upper intervertebral disc angle difference		Vertebral wedge angle difference		Anterior vertebral body height difference	
		Mean ± SD	p-value	Mean ± SD	p-value	Mean ± SD	p-value	Mean ± SD	p-value	Mean ± SD	p-value
Endplate											
Superior	○	15.1 ± 4.5	0.026	2.4 ± 2.0	0.302	4.3 ± 3.3	0.333	8.4 ± 2.8	0.137	1.8 ± 1.1	0.665
	○	7.2 ± 3.4		0.8 ± 1.3		2.9 ± 2.4		7.4 ± 3.8		0.8 ± 1.1	
	×	5.2 ± 1.9		0.6 ± 2.1		5.7 ± 2.5		1.1 ± 2.7		1.2 ± 2.0	
Inferior	○	14.9 ± 3.8	0.187	2.1 ± 2.8	0.398	5.2 ± 2.1	0.640	3.4 ± 2.5	0.330	3.6 ± 2.8	0.379
	○	5.6 ± 1.8		0.4 ± 2.3		3.0 ± 2.9		3.7 ± 2.6		0.9 ± 2.5	
	×	11.6 ± 3.6		1.8 ± 2.9		4.0 ± 3.2		8.2 ± 3.0		1.2 ± 1.7	

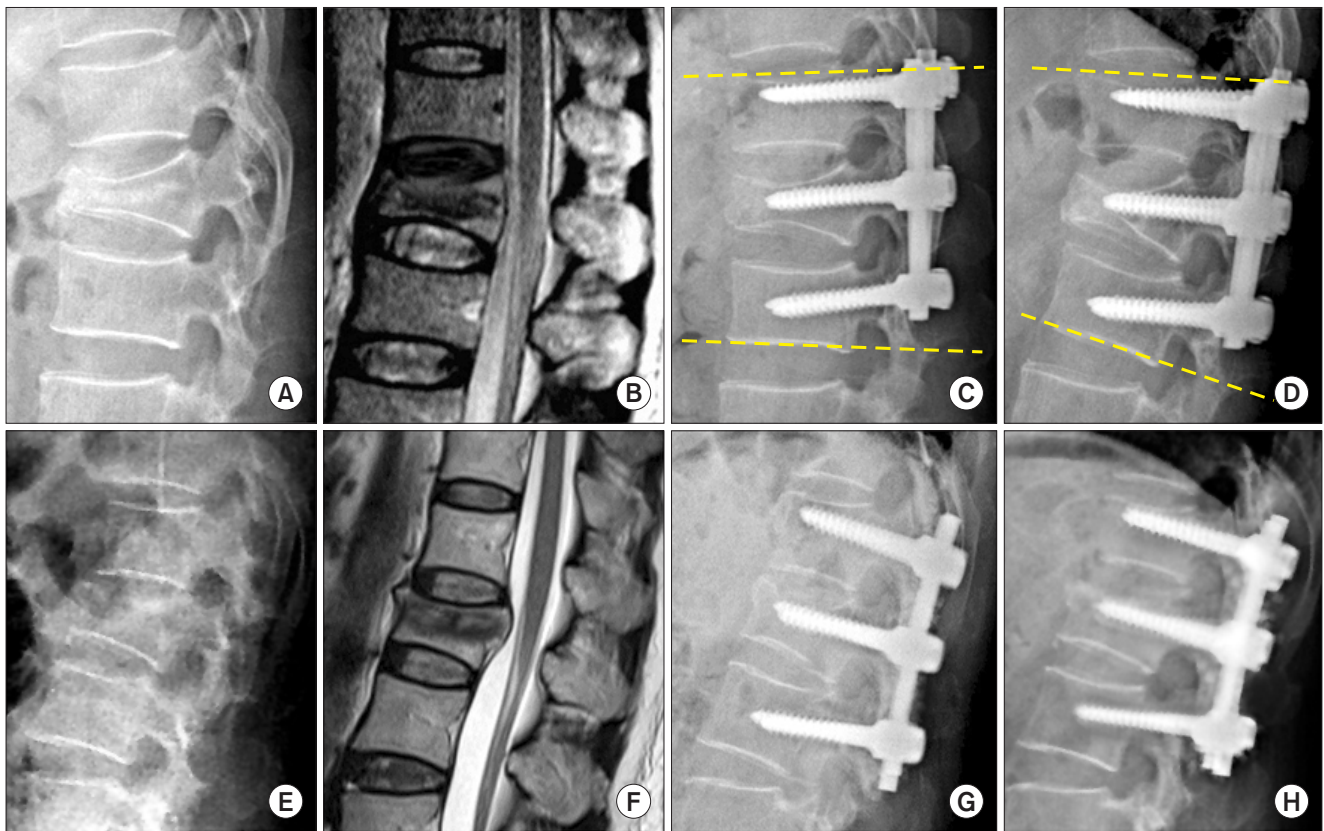
SD: standard deviation.

alone, SDEC injury, and none of the injuries (Fig. 3). A significant difference was also observed in the change in CA ( $p = 0.029$ ) and VWA ( $p = 0.047$ ) between patients with a SDEC injury and those with a superior endplate injury alone (Table 3).

## DISCUSSION

This study revealed the relationship between preoperative SDEC injury and correction loss after SSPSF with a bone graft in young adult patients with a STLBF. Jun et al.<sup>9)</sup> reported that ALL injury, superior endplate and disc injury, and high level of bone edema were critical factors that determine the progression of a kyphotic deformity in conservatively treated STLBFs. However, there are only a few reports on the influence of disc and endplate injury on the postoperative outcomes in patients with STLBFs. Age, osteoporosis, and degree of comminution of the vertebral body are the known risk factors for poor surgical outcomes in thoracolumbar burst fractures.<sup>10,11)</sup> In this study, we assessed the influence of disc and endplate injury in adult patients younger than 45 years and diagnosed with an STLBF without any injury to the posterior structures.

Although collapse of the disc common in STLBFs, the mechanism has yet to be established. A disruption of the vascularity of the endplates is believed to be one of the major causes of the degenerative disc disease.<sup>12,13)</sup> Zhao et al.<sup>14)</sup> noted that when the vertebrae are compressed naturally by the adjacent intervertebral discs, superior endplates usually fail before the inferior endplates because they are thinner and supported by less dense trabecular bone. The vertebral endplates contain marrow cavities that allow the bone marrow to lie adjacent to the calcified hyaline cartilage, which is widely regarded as an important route for metabolite transport.<sup>15)</sup> An endplate injury is likely to result in disc degeneration due to calcification and blocking of the endplate's nutritional route. In the present study, a disc injury did not occur solely but appeared only in association with an endplate injury. A disc injury occurs after an endplate injury develops. Changes in radiological parameters of reduction loss during the postoperative follow-up had no significant association with an ALL injury, PLL injury, level of vertebral injury, and inferior structure (disc/endplate) injury. On the other hand, a superior structure (disc/endplate) injury had a statistically significant influence on the CA and VWA. Furthermore, combined injury to the superior disc and endplate was more common than that to the inferior disc and endplate, and SDEC injury occurred more frequently than superior endplate injury alone. In light of these findings, we believe



**Fig. 3.** (A-D) Magnetic resonance imaging (MRI) scans and X-rays showing correction loss in a patient with superior disc-endplate injury. The Cobb angle decreased (dotted lines) in the patient. (E-H) MRI scans and X-rays of a patient without correction loss. (A, E) Initial X-rays. (B, F) Initial T2 MRI scans. (C, G) Postoperative X-rays. (D, H) One-year follow-up X-rays.

**Table 3.** Impact of the Superior Disc-Endplate Complex and Superior Endplate Injury Alone

Presence of injury	No.	<i>p</i> -value				
		Cobb angle difference	Intervertebral disc height difference	Upper intervertebral disc angle difference	Vertebral wedge angle difference	Anterior vertebral body height difference
Superior disc-endplate complex	20	0.029	0.146	0.307	0.047	0.454
Superior endplate alone	12					

that the frequency of SDEC injury is high in patients with STLBFs, and SDEC injury appears to influence postoperative radiological results.

Rigid screw fixation with fusion might also lead to stress shielding of the intervertebral disc, resulting in biochemical changes.<sup>16)</sup> Previous MRI studies showed that the signal intensity change of the disc was observed in most cases and the most significant changes were related to morphological alterations in the disc space.<sup>17,18)</sup> Posterior reduction with pedicle screw instrumentation probably reduces only the periphery of the endplate with its strong

annular attachments, while the central area remains depressed. Therefore, one of the major mechanisms of loss of correction may be the creeping of the disc back into the central depression of the endplate. Knop et al.<sup>19)</sup> showed that the VWA on the initial injury film correlated significantly with the postoperative loss of reduction. The present study showed that the postoperative VWA was related to SDEC injury. Interestingly, the group with an SDEC injury and the group with a superior endplate injury only showed similar changes in the IDH and UIDA during the postoperative follow-up, but significant differences

between the groups were noted in the changes of CA and VWA. The presence of disc injury had been expected to affect the postoperative disc height and disc angle. However, we found that disc-endplate complex injury could have a greater impact on the vertebral body morphology compared to an endplate injury alone. In addition, disc injury appeared to have an insignificant impact on the disc morphology. Such short-term follow-up findings may be attributed to six-screw fixation and rigid fixation with bone grafting. However, it is difficult to predict correction loss based on the follow-up radiograph because the correlations among the variable parameters were relatively weak. To decrease correction loss, surgeons who perform SSPSF should pay more attention to restoring the fractured VWA.

The addition of pedicle screws in the fractured vertebra improves fracture reduction, and through the lordosis effect, provides a better chance of placing the fractured vertebral body in front of the gravity line.<sup>20)</sup> Simultaneously, it creates a buttress effect that allows vertebral body fracture healing before collapse. In the present study, there were only four cases with a load sharing classification score higher than 7 points. However, this study was not designed to examine the effects of vertebral body comminution on radiological outcomes and compare the study results according to the load sharing classification score. We performed fixation using six pedicle screws in the superior and inferior vertebral bodies including the

fractured area for stabilization of the fracture site. Despite the remaining controversy over the treatment efficacy, bone union and slight correction loss were observed and the integrity of pedicle screw fixation using an allograft was maintained in the first postoperative year. Additional studies are needed to determine if the anterior support is essential considering the posterior column and posterior ligament complex are intact in STLBFs.

This study had some limitations. Clinical outcomes were not included in the analysis; thus, the relationship between radiological findings and clinical outcomes is still a matter of discussion. Further research involving a larger patient population and a more long-term follow-up is warranted to address the unresolved issue. Other limitations include the retrospective study design and assessment of parameters on the lateral plain radiographs.

A superior intervertebral disc-endplate complex injury may have an impact on the prognosis after short-segment fixation in young adult patients who have a STLBF. Correction loss after SSPSF assessed by CA and VWA may be associated with superior intervertebral disc-endplate complex injury in STLBFs.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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